Open Access
J. Glob. Innov. Agric. Sci., 2023, 11(1):27-33.
ISSN (Online): 2788-4546; ISSN (Print):2788-4538
DOI: https://doi.org/10.22194/JGIAS/11.1033
http://www.jgiass.com

Morpho-physiological responses of wheat (*Triticum aestivum* L.) to foliar applied potassium under different planting geometry

Bader Ijaz[1], Ejaz Ahmed Waraich[1], Aka Khil[1], Fahad Waris[1], Ahmad Shah[2], Shahid Nazeer[1,*], Muhammad Sajjad[1], Faisal Mustafa[1], Ahmad Abdul Wahab[3], Muhammad Hammad[4] and Faryal Ahmed[1]

[1]Department of Agronomy, University of Agriculture Faisalabad, Pakistan; [2]Nangarhar University, Afghanistan. Department Agricultural Economics & Extension, Pakistan; [3]Department of Agronomy, Faculty of Agricultural Sciences and Technology, Bahauddin Zakariya University, Multan, Pakistan; [4]Seed Analyst, Federal Seed Certification and Registration Department-Islamabad, Pakistan
*Corresponding author's e-mail: nazeershahid46@gmail.com

Potassium deficiency is well known worldwide. Potassium deficiency causes many types of abnormalities in both humans and plants. Potassium is an important nutrient for plants. Its deficiency reduces chlorophyll formation, growth, yield and tillering capacity in plants. To evaluate the growth and yield of wheat to various potassium levels under different planting geometry. A field study was managed at Postgraduate Agriculture Research Station Faisalabad during the year 2018-2019. Experiment was comprised of four levels of potassium control, water foliar application, potassium foliar application @ 0.25 g and potassium foliar application @ 0.5 g with three panting geometries (bed sowing, line sowing at 22.50 cm and broadcast). Muriate of potash (25 % K_2O) was applied as a potassium source. In all treatments, nitrogen and phosphorus were used @ 150 and 100 kg ha^{-1} respectively. The experiment was replicated 3 times and was carried out in split plot arrangement, randomizing the potassium levels were in sub plots and planting geometry in main plots. Net plot size was maintained as 6 ft x 6 ft. Potassium was applied at different levels in the different treatments at the time of sowing. All of the potassium (K) phosphorous (P) with half of nitrogen (N) was applied at the time of sowing while remaining amount of N was given with first irrigation. First irrigation was done after 23 days of sowing. Growth and yield data were recorded and analyzed statistically using Fisher analysis of variance techniques and differences among the treatment means were compared using Tuckey's test at 5% probability level. Results showed that yield-related characteristics such as productive tillers, spikelets per spike, number of grains per spike, significant and maximum grain weight more emergence count (m^{-2}), 1000-grain weight (g), biological yield and grain yield (t ha^{-1}) was recorded where potassium levels were applied at the rate 0.25% and 0.5% as compare to control and water foliar application, that means foliar application of potassium significantly increase the per acre yield of wheat crop. Planting geometry has also shown a substantial response to growth, yield characteristics and the concentration of grain potassium.
Keywords: Wheat, foliar application, response, planting geometry and potassium.

INTRODUCTION

Wheat is leading world food crop. It ranks first amongst Pakistan's cereal crops. Pakistan's stability is directly and indirectly dependent upon proper wheat husbandry. The present study focused primarily on the impact of various potassium concentrations and planting methods on wheat growth and its yield.

The choice of appropriate planting method and potash level can play a major role in yield for better crop stand. (Anwar *et al.* 2011) described that crop's planting geometry regulates solar radiation interception, coverage of crop canopies and accumulation of total dry matter. Optimum plant spacing ensures that plants grow accurately by different solar radiation utilization and nutrients in both their above and underground components. The optimal density of plants

Ijaz, B., A. Khil, F. Waris, A. Shah, S. Nazeer, M. Sajjad, A.A. Wahab, M. Hammad, F. Ahmed, E.A. Waraich,' F. Mustafa, A.A. Wahab, M. Hammad and F. Ahmed. 2023. Morpho-physiological responses of wheat (*triticum aestivum* l.) to foliar applied potassium under different planting geometry. Journal of Global Innovations in Agricultural Sciences 11:27-33.
[Received 7 Nov 2022; Accepted 28 Dec 2022; Published 6 Mar 2023]

depends upon various factors such as plant characteristics, planting time, plant size, growth cycle, fertility of the soil, sunlight, availability of moisture, planting patterns and infestation of weeds (Shirtliffe and Johnston, 2002).

Potassium plays a key role in opening and closing of stomata, photosynthesis, osmoregulation and protein preparation (Cakmak, 2005). For the proper functioning of many significant physiological and biochemical processes that directly assess crop productivity, the potassium contents in plant tissues is crucial. Crop yield is related to potassium fertilization and soil's potential potassium supplying capacity. The application of potassium in the foliar form decreases the harsh effects of water shortage in drought situation. Foliar K application enhanced the yield components and grain yield. It is proved by research that micronutrients can help in the overall output enhancement (Nazeer *et al.*, 2020). Although the foliar applied potassium at the grain filling stage positively manage adverse impact of the water shortage on the amount of spikelets/spike, the weight of 1000-grains and the yield of grain. The fertilizer application method is very important for the nutrients supply to the plants. Most potassium is dehydrated in soils and coordinated into oxygen atoms not available to plants. Foliar application is very important for the rapid supply of nutrients to plants, but it cannot be applied to all crops because certain nutrients can cause leaf blisters in some plants (Fageria *et al.*, 2009).

The height of the plant, spikelets per spike and lodging ranking were associated oppositely with yield of grains. Transverse osmotic pressure in root system is produced when xylem parenchyma cells force out potassium into xylem vessels, reducing the ability for water to enter and creating uptake of water possible. The existence of K in the vacuole indicates the conservation of potassium and the essential osmoticum. The osmotic function is unspecific since it can be controlled by several organic and inorganic osmotica in plants. Potassium is not only principal nutrient for growth of plant but it is also mandatory for health of human. In plants potassium carries out various reactions that are oxidative reductive, transfer energy, metabolic processes, metabolism of nitrogen, enzymatic reactions and composition of protein. Potassium is moreover a co-factor too for various enzymes like dehydrogenases, peroxidases, oxidases and as well as anhydrases that are needed for many plant processes.

While, taking into account the importance of potassium, a field study was managed to evaluate the effect of various potassium levels in wheat under different planting geometries.

MATERIALS AND METHODS

This research was performed during 2019-20 at the Postgraduate Agriculture Research Station (PARS) Faisalabad (latitude 31^0N, longitude 73^0E) Pakistan. Experiment was performed in split plot arrangement, randomizing the levels of potassium in subplots and planting geometry main plots. 1.8 m x 3 m was maintained as plot size. The experiment consists on following treatments. Factor A: include various methods of potassium application T_0 = Control (without any potassium application), T_1 = Foliar application of water, T_2 = Potassium foliar application @ 0.25% potassium solution and T_3 = Potassium foliar application @ 0.5% potassium solution and Factor B: comprises of various Planting Geometry P_1 = Bed Planting, P_2 = Flat sowing (Line Sowing) and P_3 = Flat Sowing (Broadcasting).

On the last week of November, wheat crops was sown using a seed rate of 125 kg ha^{-1}. Different geometries for planting were used. Faisalabad-2008 was the crop variety. For NPK analysis, soil sampling was done prior to crop sowing. The soil analysis data given in Table 1.

Table 1. Physio-chemical analysis of experimental unit.

Characteristics	Unit	Value
EC	dSm^{-1}	0.30
Ph	-	8.21
Organic Matter	%	0.90
Nitrogen	%	0.07
Phosphorus	Ppm	5.1
Potassium	Ppm	161.50
Texture	-	Sandy loam

Nitrogen and phosphorus were added to all treatments at a rate of 150 and 100 kg ha^{-1} respectively. In the various treatments at the time of sowing, potassium was added at different amounts. While the half nitrogen phosphorous and potash were applied at sowing time, with first irrigation, the subsequent amount of N was given. The detail of all necessary weather indices during crop growing season is represented below.

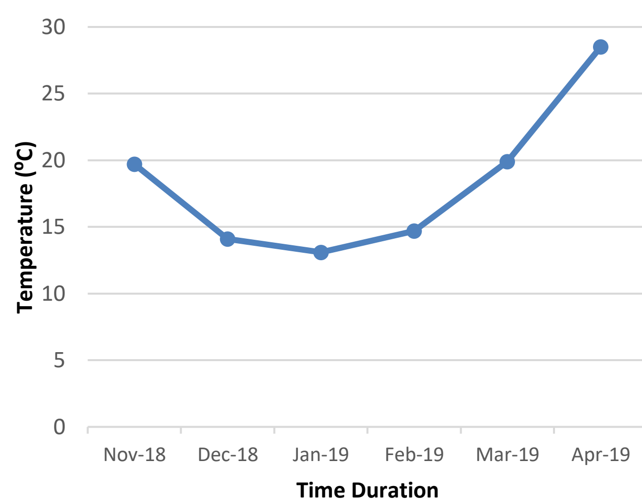

Figure 1. Monthly mean temperature during Rabi season 2019-20.

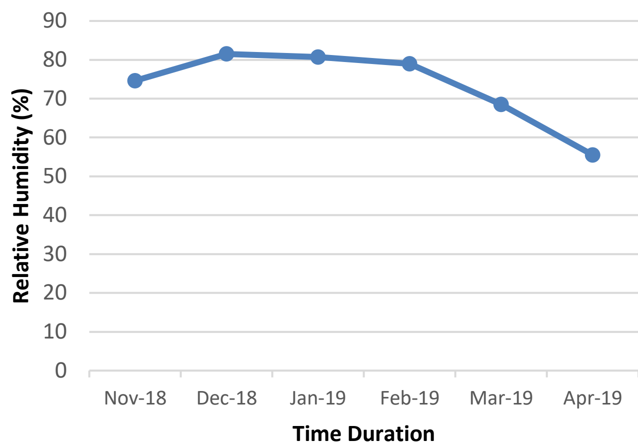

Figure 2. Monthly means of relative humidity through Rabi season 2019-20.

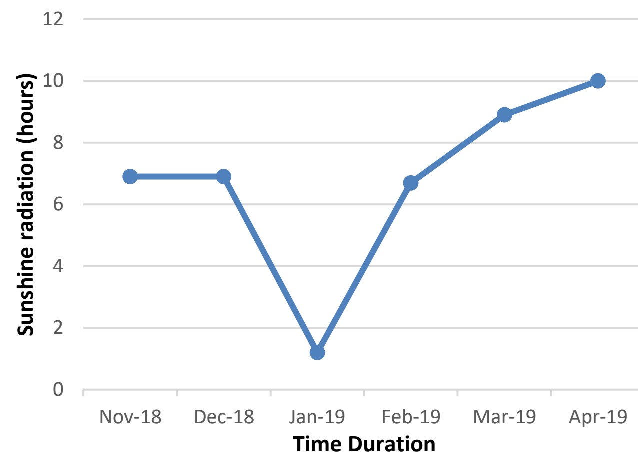

Figure 5. Monthly averages of sunshine duration during Rabi season 2019-20.

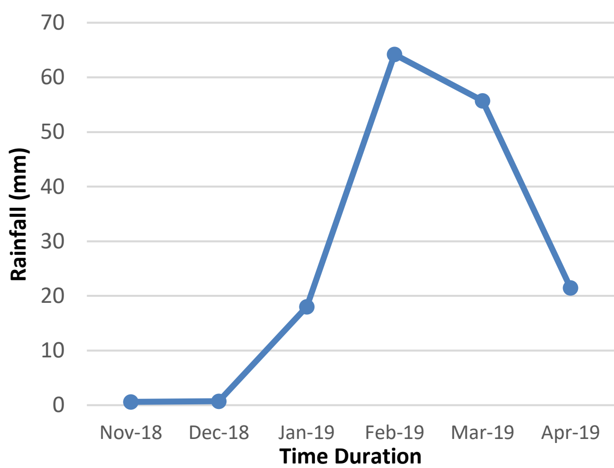

Figure 3. Monthly means of rainfall during Rabi season 2019-20.

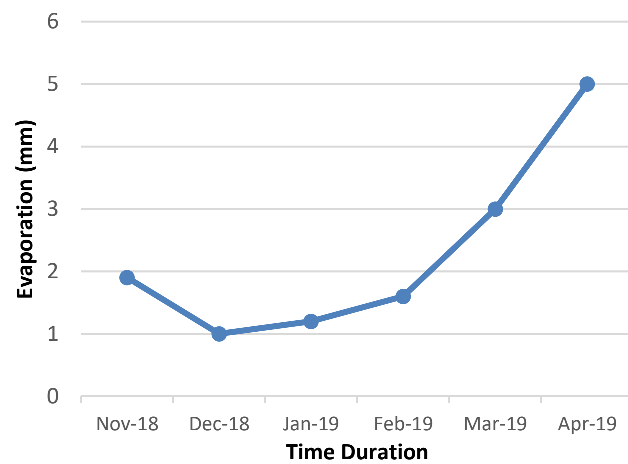

Figure 6. Monthly means of evaporation during Rabi season 2019-20.

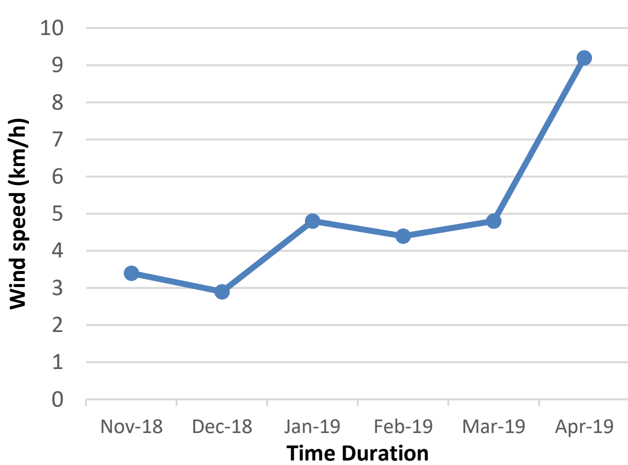

Figure 4. Monthly means of wind speed during Rabi season 2019-20.

RESULTS AND DISCUSSION

***Plant height (cm)*:** Plant height data showed that different potassium levels, planting geometry and the relationship between them were significant. The maximum height (76.67 cm) was obtained where water foliar application was used followed by potassium 0.25 g and then where potassium was applied at a rate of 0.5 g while minimum (74.67 cm) was observed in control. A minute variation may be due to genetic variability. Increased plant height at moderate and augmented levels of K fertilizer owing to appropriate accessibility of essential nutrients which caused enhance in plant growth. Same findings described by (Ayoub *et al.*, 1994) and (Maqsood *et al.*, 1999).

***Total number of tillers (m^{-2})*: Table 2** presents the data relating to amount of tiller (m^{-2}) of various planting geometries influenced by various doses of K. Data relating

Table 2. Effect of foliar applied potassium under different planting geometry on yield and yield components.

Treatments	Plant height (cm)	Number of tiller /m^2	Spike length (cm)	Number of spikelets /spike	Number of grains /spie	1000 grain weight (g)	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Control (T_0)	74.67 D	234.67 C	7.91 D	10.11 D	29.22 D	34.09 D	3.47 D	11.47 D	37.42 B
Foliar application of water (T_1)	76.67 A	281.67 A	11.31 B	14.55 B	39.88 B	39.37 B	4.41 B	14.10 B	41.45 A
0.25% potassium solution (T_2)	76.11 B	281.67 B	9.67 C	12.44 C	35.55 C	37.10 C	4.11 C	12.73 C	43.45 A
0.5% potassium solution (T_3)	75.46 C	282.33 B	13.53 A	16.66 A	44.22 A	44.83 A	5.90 A	15.73 A	43.43 A
HSD value	2.1531	3.9415	0.2047	1.4220	2.0714	0.6729	0.0958	0.3696	0.1067
Bed Planting (P_1)	81.50 B	261.25 A	9.73 C	11.83 B	33.25 C	34.96 C	4.05 C	13.05 C	41.82
Line Sowing (P_2)	83.50 B	267.25 A	10.13 B	12.75 B	35.66 B	37.63 B	4.31 B	13.35 B	41.44
Broadcasting (P_3)	101.25 A	295.00 A	11.96 A	15.75 A	42.75 A	43.96 A	5.06 A	14.13 A	41.98
HSD value	2.3956	3.2414	0.3140	1.1380	1.5344	0.4027	0.0928	0.0840	NS
T_0 x P_1	65	220	7.00	8.33	24.33	30.13	3.00	11.00	38.23
T_0 x P_2	71	225	7.40	9.33	26.66	33.10	3.30	11.20	38.24
T_0 x P_3	88	259	9.33	12.66	36.66	39.03	4.10	12.20	35.84
T_1 x P_1	86	270	10.43	13.00	37.33	35.30	4.01	13.60	41.08
T_1 x P_2	87	278	10.80	14.00	39.66	37.70	4.23	14.00	40.14
T_1 x P_3	106	297	12.70	16.66	42.66	45.10	5.00	14.70	43.14
T_2 x P_1	80	241	9.00	10.66	31.00	34.00	3.70	12.30	44.36
T_2 x P_2	78	245	9.40	11.33	33.66	36.20	4.00	12.60	41.72
T_2 x P_3	97	274	10.60	15.33	42.00	41.10	4.64	13.30	44.26
T_3 x P_1	95	314	12.50	15.33	40.33	40.40	5.50	15.30	42.36
T_3 x P_2	98	321	12.90	16.33	42.66	43.50	5.70	15.60	43.44
T_3 x P_3	114	250	15.20	18.33	49.66	50.60	6.50	16.30	44.48
HSD value	NS	NS	NS	NS	NS	NS	NS	NS	NS

total no. of tillers m^{-2} indicate that planting geometry have non-significant impact on total number of tillers (m^{-2}) while various K concentrations have noteworthy role on the tillers number. The highest number of tillers (m^{-2}) (282.33 m^{-2}) was obtained where K was used as 0.5 g followed by water foliar application and by 0.25 g potassium application, while minimum (234.67 m^{-2}) were noted in control. Interaction of both factors was also noteworthy. Outcomes are in lined with the finding of (Hussain *et al.*, 2002). They find that potassium significantly affected the total tillers number.

***Spike length (cm)*:** Table 2 presents data relating to spike lengths of three distinct planting geometries and four potassium levels. The abridged ear length at flowering stage is owing to abridged node to node distance on the rachis. Furthermore, it was too detected by (Yadav *et al.*, 2004). Given data showed that K level and planting geometry significantly affect spike length. Among the K levels, more spike length (13.53 cm) was observed where K was used at the rate of 0.5 g followed by water application, followed by 0.25 g while minimum (7.91 cm) were calculated from control. Interaction of both factors was also more noteworthy. These finding were supported by (Abbas *et al.*, 2013). They find that the length of spike is considerably affected by use of potassium.

***Number of Spikelets per spike*:** The collected data showed that K levels and planting geometry significantly affect while and the interactions of both factors are non-significant effect on no. of spikelets/spike. As regards the maximum number of spikelets per spike (16.66) was counted where K was used at the rate of 0.5 g followed by water application, followed by 0.25 g potassium foliar application while minimum (10.11) were obtained in control. Deficiency of any essential nutrients at flowering can reduce photosynthetic activity which ultimately cause unfertile kernel. Abbas *et al.* (2013) also determined that spikelets per spike are meaningfully augmented by use of potassium.

***Number of grains per spike*:** Results about the number of grains per spike revealed that dose rate of potassium and planting geometry of wheat have supplementary noteworthy influence. Maximum number of grains per spike (44.22) was observed 0.5 g dose rate of potassium, followed by water application and 0.25 g, while minimum (29.22) were calculated from control. Interaction of both factors was too noteworthy. Entire dose rates of K caused expressively more number of grains than the control plot. The findings corroborated with previous results (Gwal *et al.*, 1999) and (Maqsood *et al.*, 1999).

***1000-grains weight (g)*:** Data regarding 1000-grains weight indicate that K levels and various planting types have significantly effect on 1000-grain weight. The highest 1000 grain weight (44.83 g) was detected where K was used at the rate of 0.5 g, followed by water application while minimum

(34.09 g) were recorded from control. Interaction of both factors was also more significant. Due to less absorption from soil the movement of food particles was also reduced which major part for grain filling. K also is a main part of different enzymes effect on starch production. Starch synthesis is the major events in grains. That's why K is necessary for grain formation. These findings are in lined with (Dilshad *et al.*, 2000) and (Ijaz, 2004). They conclude that the 1000-grain weight of wheat increases through adding fertilizer to crop.

***Grain yield (t ha^{-1})*:** Data regarding grain yield (t ha^{-1}) showed that the planting geometry of wheat and potassium levels have more significant effect on grain yield (t ha^{-1}). The more grain yield (5.90 t ha^{-1}) was recorded where K was used at the rate of 0.5 g, followed by water application, followed by 0.25 g, while minimum (3.47 t ha^{-1}) were observed in control. Soil application have a drawback that plants not absorb nutrients properly so it effect on grain yield. Although K is a major components of various enzymes which involve in grain production. Starch synthesis is one of the major process in grains. That's why K availability positively effect on grain yield. These re sults are similar with (Xiong *et al.*, 2003) and (Wilhlem and White, 2004)

***Biological yield (t ha^{-1})*:** Data represent in Table 2 showed that K levels significantly effect on biological yield of wheat crop. The highest biological yield (15.73 t/ha) were obtained where K applied at the rate of 0.5 g while lowest biological yield (11.47 t/ha) was observed in control treatment. Highest dry matter production was recorded from rice crop by the application K fertilizer. These findings are in lined with the research of (Pettigrew, 2008). K is the fundamental elements of growth yield and quality of various crop plants.

***Harvest Index (%)*:** data indicate that various K levels have significantly affected the harvest index, while planting geometry did non-significantly effect on harvest index (**Table 2**). The interaction affect was also found non-significant. As regards, the maximum harvest index (43.43) was recorded in case of 0.25 g potassium application while minimum harvest index (37.42) was found in control treatment. These results can be related with the work of (Abbas *et al.*, 2013) who concluded that harvest index of wheat crop increase with increasing of K dose.

***Shoot Fresh Weight (g)*:** The fresh weight of the shoot is recorded immediately after the harvest of the plant. It is evident from Table 3 that the effect of potassium treatment foliar spray was highly significant ($p < 0.05$) potassium application at the rate of 0.5 g significantly increased the fresh weight of the shoot over control and other potassium levels. The planting geometry was non-significant that means that different planting geometry had not the effect on the yield of wheat. The interaction of potassium and planting geometry was highly significant in this trait and it also affected shoot fresh weight. The means of treatments were significant as

Table 3. Effect of foliar applied potassium under different planting geometry on growth and physiological parameters.

Treatments	Shoot Fresh Weigh (g)	Shoot Dry Weight (g)	Flag Leaf Area	Water Potential	Osmotic Potential	Turgor Potential
Control (T_0)	1.93 A	0.33	36.89 B	0.93 A	1.30 B	0.35 C
Foliar application of water (T_1)	1.73 A	0.29	36.40 C	0.90 A	1.36 B	0.48 B
0.25% potassium solution (T_2)	1.72 A	0.29	36.66 C	0.91 A	1.43 A	0.53 A
0.5% potassium solution (T_3)	2.08 A	0.31	37.82 A	0.84 B	1.49 A	0.46 B
HSD value	0.2023	NS	0.3053	0.1434	0.0671	0.0351
Bed Planting (P_1)	1.88	0.30	37.11 A	0.88 B	1.39 A	0.45 B
Line Sowing (P_2)	1.84	0.31	36.45 B	0.88 B	1.43 A	0.48 A
Broadcasting (P_3)	1.87	0.31	37.02 A	0.93 A	1.38 A	0.45 B
HSD value	NS	NS	0.3851	0.0224	0.0999	0.0284
T_0 x P_1	2.00	0.33	37.86	0.93	1.28	0.35
T_0 x P_2	2.10	0.33	36.00	0.90	1.27	0.35
T_0 x P_3	1.70	0.32	36.08	0.95	1.36	0.34
T_1 x P_1	1.80	0.28	34.90	0.82	1.40	0.42
T_1 x P_2	1.63	0.31	36.80	0.86	1.51	0.50
T_1 x P_3	1.76	0.29	37.50	0.01	1.16	0.53
T_2 x P_1	1.63	0.27	39.20	0.93	1.43	0.63
T_2 x P_2	1.80	0.31	34.23	0.87	1.43	0.58
T_2 x P_3	1.73	0.30	35.56	0.94	1.44	0.38
T_3 x P_1	2.10	0.31	36.46	0.82	1.43	0.38
T_3 x P_2	1.83	0.30	38.76	0.88	1.49	0.48
T_3 x P_3	2.30	0.31	38.23	0.83	1.54	0.53
HSD value	NS	NS	NS	NS	NS	NS

shown in the given table. At potassium application at the rate of 0.5 g, maximum shoot fresh weight (2.08 g) was observed and the minimum was where potassium was applied at the rate 0.25 g (1.72 g). These results are similar with previous studies of (Cakmak, 2009) who reported that application of potassium significantly improved yield components such as water potential.

***Shoot Dry Weight (g)*:** The calculation of oven-dried specimens is the standard means of assessing shoot dry weight (SDW). In this process, the tissue is harvested and dried, and at the end of the experiment, the dry weight is weighed. It is evident from Table 2 that the various potassium levels, different planting geometry and their interactions did not affect the shoot dry weight.

***Flag Leaf Area*:** The statistical analysis of data on the flag leaf area affects three wheat planting geometries and four separate K levels are presented in Table 3. Statistics on the flag leaf area effects K levels, planting geometry and the relationship of potassium levels with the planting geometry revealed a highly noteworthy impact on the flag leaf area. By regard to potassium concentrations, the maximum flag leaf area was observed (37.82) where potassium was applied at a rate of 0.5 g followed by control and 0.25 g while the minimum (36.40) was observed under water application. The present study results can be related with the previous study of (El-Abady *et al.*, 2009).

***Water Potential*:** The capacity of water varies between cultivars or may differ depending on the genetic makeup and environmental conditions. It is evident from Table 3 that the effect of foliar spray of potassium treatments was highly significant ($p < 0.05$) and the planting geometry was also highly significant that's mean different planting geometry had the different effect on the yield of wheat Similarly the interaction of potassium and planting geometry was also highly significant in this trait and it also affected water potential. The means of treatments were significant as shown in the given table. At no application of potassium maximum water potential (0.93) was obtained against water application, 0.25 g potassium foliar application and minimum (0.84) was where 0.5 g potassium application was done. These results are line with previous studies of (Cakmak, 2009) who reported that application of potassium significantly improved yield components such as water potential.

***Osmotic Potential*:** Osmotic potential is often encountered by a soil solution. There is a need for a semi-permeable membrane because it allows water through its membrane while preventing the movement of solutes through its membrane. The statistical analysis of data on the osmotic potential affects three wheat planting geometries and four separate K levels are presented in Table 3. Statistics on the osmotic potential effects K levels, crop geometry and the relationship of potassium doses with planting geometry revealed a highly noteworthy impact on the osmotic potential. With regard to potassium concentrations, the maximum osmotic potential was observed for maximum potassium concentrations (1.49) where potassium was applied at a rate of 0.5 g followed by 0.25 g, followed by foliar application of water, while the minimum (1.30) was observed under control.

***Turgor Potential*:** Data regarding turgor potential influenced by different doses of K and planting geometry are given in**Table 3** . Results of turgor potential revealed that different potassium levels and planting geometry of wheat have highly noteworthy impact on turgor potential. Highest turgor potential (0.53) was recorded where K was used at the rate of 0.25 g, followed by water foliar application, followed by 0.5 g potassium application while minimum (0.35) were observed in control. These results can be related with (Xiong *et al.*, 2003), (Wilhelm and white, 2004).

***Conclusion*:** The present experimental study revealed that where potassium levels were applied at the rate 0.25% and 0.5% as compare to control and water foliar application, that means foliar application of potassium significantly increase the per acre yield of wheat crop.

***Authors Contributions statement*:** All authors have equally contributed to conduct this trial.

Conflict of interest: No conflict of interest is declared by authors

***Acknowledgement*:** The facilitation provided by honorable supervisor Dr. Ejaz Ahmed Waraich for his highly acknowledged.

REFERENCES

Abbas. G., J.Z. K. Khattak, G. Abbas, M. Ishaque, M. Aslam, Z. Abbas, M. Amer and M.B. Khokhar. 2013. Profit maximizing level of potassium fertilizer in wheat production under arid environment. Pakistan Jornal of Botany 45:961-965.

Anwar M.P. A., S. Juraimi, A. Puteh, A. Selamat, A. Man and M.A. Hakim 2011 method and rate influence on weed suppression in aerobic rice. African Journal of Biotechnology 10:15259-15271.

Ayoub, M., S. Guertin, S. Lussier and D.L. Smith. 1994. Timing and level of nitrogen fertility effects on spring wheat yield in eastern Canada. Journal of Crop Sciences 34:748-56.

Cakmak, I. 2005. The role of potassium in alleviating detrimental effects of abiotic stresses in plants. Journal of Plant Nutrition and Soil Science 168:521-530.

Cakmak, I., 2009. Enrichment of fertilizers with potassium: An excellent investment for humanity and crop production in Journal of Trace Elements in Medicine and Biology 23:281-289.

Dilshad, M., R. Khalid, A. Hussain, M. Ahmad and K H. Gill. 2000. Response of crop to the application of potassium (K) under Gulliana and Missa soil series. In: Abstracts of the paper presented at the 8th International congress of soil science, 13-16, November 2000, NARC., Islamabad, Pakistan.

El-Abady, M.I., S.E. Seadh, A. El-Ward, A. Ibrahim, and A.A. El-Emam. 2009. Irrigation withholding and potassium foliar application effects on wheat yield and quality. International Journal of Sustainable Crop Production 4:33-39.

Fageria, N.K., M.P.B. Filho, A. Moreira and C.M. Guimaraes. 2009. Foliar fertilization of crop plants. Journal of Plant Nutrition 32:1044-1064.

Gwal, H.B., Tiwari, R.J., Jiaan, R.C. and Prajapati, P. S. 1999. Effect of different levels of fertilizer on growth, yield and quality of late sown wheat. RACHIS Newsletter 18:42-43.

Hussain, M. I., S. H. Shah, H. Sajjad and K. Iqbal. 2002. Growth, yield and quality response of three wheat (*Triticum aestivum* L.) varieties to different levels of N, P and K Int. International Journal of Agriculture and Biology 3:362-364.

Ijaz. U. 2004. Response of rice and wheat crops to potassium fertilization in saline sodic soils. M.Sc. Thesis, Dept. of Soil Science, University of Agriculture, Faisalabad.

Maqsood, M., M. Akbar, N. Yousaf, M.T. Mehmood and S. Ahmad. 1999. Effect of different rates of N, P and K combinations on yield and components of yield of heat. International Journal of Agriculture and Biology 1:359-361.

Nazeer, S., M. Tahir, M. Sajjad, M. Idrees, M.A. Saleem, A. Shehzad and M.U. Hameed. 2020. Response of Different Micronutrients (Zn, Cu and Mn) Soil Application on Yield and Quality of Late Sown Wheat (*Triticum aestivum* L.) under Faisalabad Conditions Pakistan Journal of Life & Social Sciences 18:65-70.

Pettigrew, W. T. 2008. Potassium influence on yield and quality production for maize, wheat, soybean and cotton. Physiology of Plant 133:670-681.

Shirtliffe, S.J. and A.M. Johnston. 2002. Yield density relationships and optimum plant.

Wilhelm, N. and J. White. 2004. Potassium responses observed in South Australian cereals. Better Crops with plant food 88:28-31.

Xiong, M., S. Fen, S. Guang Yu, S. Xiaojun and M. Zhi Yun. 2003. Effect of long term potassium application on yield and soil potassium in rice-wheat cropping system in purple soil. Acta Pedologica Sinica 40:274-279.

Yadav, R.S., C.T. Hash, F.R. Bidinger, K.M. Devos and C.J. Howarth. 2004. Genomic regions associated with grain yield and aspects of post flowering drought tolerance in pearl millet across environments and tester background. Euphytica 136:265-277.